The Role of Infrastructure in the Rural – Urban Digital Divide

Brian E. Whitacre
Graduate Research Assistant
bwhitacr@vt.edu

Bradford F. Mills
Associate Professor
bfmills@vt.edu

Department of Agricultural and Applied Economics
Virginia Polytechnic Institute and State University

Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island, July 24 – 27, 2005.

Introduction

Differences in residential Internet access rates (digital divides) have been well documented for high and low education households (NTIA, 1999; 2000) and for high and low income households (Pearce, 2001). Similarly, a divide between households in rural and urban areas has been the focus of a number of studies (Malecki, 2003; Strover, 2001).[1] Differences in rural and urban distributions of household characteristics have been shown to explain a significant share of the rural – urban divide. Mills and Whitacre (2003) find that differences in household characteristics, particularly lower income and education levels in rural areas, account for approximately two-thirds of the rural – urban gap in general residential Internet access in 2001. Less racial diversity, higher levels of dual-headed households, older households heads, and lower rates of access from work in rural areas relative to urban areas also contribute to the observed gap (McConnaughey and Lader, 1998; NTIA, 2000; Rose 2003). Network externalities may also play a role. Many Americans use the Internet to become more connected with their local community (Horrigan, 2001). Hence, the value of the Internet to a household may increase with the share of other households in the region that are connected.

Less is known about the emerging divide in high-speed access.[2] Figure 1 shows rates of Internet access for rural and urban households in 2000, 2001, and 2003. While the rural –

[1] This paper uses the 1993 U.S. Census designations of non-metropolitan and metropolitan counties to compare rural - urban area differences in home Internet use. Metropolitan counties generally have populations greater than 100,000 (75,000 in New England) or a town or city of at least 50,000 and are referred to as urban areas. Non-metropolitan counties are those counties not classified as metropolitan and are referred to as rural areas.

[2] High-speed access, also called Broadband or advanced service, is defined as 200 Kilobits per second (Kbps) (or 200,000 bits per second) of data throughput. This is about 4 times faster than a 56Kbps dial-up modem, and about 8 times faster than most people's actual download speeds, since many ISPs' modems offer a maximum of 28.8 (Strover, 2001)

urban divide in general access has been relatively constant at around 13 percentage points over this period, the divide in high-speed access has been increasing dramatically – from 3 percentage points in 2000 to 14 percentage points in 2003.[3] There is reason to believe that the factors underlying this emerging gap in high-speed access may be different from those underlying the gap in general access. In particular, while basic dial-up service has become nearly universally available, important differences in digital communications technology (DCT) infrastructure exist in rural and urban areas that allows for high-speed Internet access. Federal Communications Commission survey data in 2000 indicates that while 70 percent of ZIP code areas in the U.S. have households that use high-speed connections, these areas contain 95 percent of the population (Prieger, 2003). Hence, the remaining 30 percent without any residential high-speed connections contain only 5 percent of the population, implying that, for the most part, those zip codes without high-speed connections are low density regions and are rural in nature.

This paper focuses on the role of DCT infrastructure in the emerging divide in high-speed residential Internet access. Three issues are explored in depth: (1) the recent diffusion of DCT infrastructure in rural and urban areas of the U.S., (2) the contribution of DCT infrastructure, as well as household characteristics and network externalities, to the emerging divide in high-speed access, and (3) the potential role of DCT infrastructure in closing the emerging divide in high-speed access.

[3] All estimates, unless noted, are based on authors' calculations using Current Population Survey Computer and Internet Use Supplements from 2000, 2001, and 2003.

Data and Descriptive Statistics

Several sources of empirical data are used in the paper. The household characteristics and local rates of access (which serve as a proxy for network externalities) are obtained from Current Population Survey Supplemental Questionnaires on Household Computer and Internet Use. These nationally representative surveys of roughly 50,000 households collect basic household member demographic and employment information on a monthly basis, while the supplement focuses specifically on residential computer and Internet use in 2000, 2001, and 2003. One drawback of this data is that the lowest level of geographic information available on a household is rural or urban status within a state. Hence, "local" rates of access cannot be calculated at the zip code or even county level. Rather, they are average access rates for all rural (urban) households in the state.

Residential Internet access is defined by a positive response to the question, "Does anyone in the household connect to the Internet from home?" Additionally, the survey identifies whether the household connects via a dial-up modem or a higher-speed connection.[4] Table 1 provides information on the number of rural and urban households in each year of the data, along with the number of households that had Internet and high-speed access in those years. Although some households were omitted due to missing or inconsistent data, there are still a large number of households in both the urban and rural samples.

[4] The 2000 CPS questionnaire only differentiates between dial-up and higher speed connections. The 2001 and 2003 questionnaires include categories for DSL, cable, satellite, and wireless (all of which are considered high-speed for the purposes of this paper).

Table 2 displays descriptive statistics for rural and urban area household characteristics that previous research suggests might affect residential Internet access. Rural households have, on average, lower education and income levels than their urban counterparts for all years. Additionally, rural areas are less racially diverse, have older household heads, and have a higher incidence of married couples than urban areas. Rural households are also more likely to be headed by a male, have no children present, and have a retired household head. It is also worth noting that rural households are much less likely to have access at work (netatwork) when compared to their urban counterparts.

Network externalities (the value that a network member obtains increases as more members enter the network) may play an important role in determining the magnitude of the benefits associated with residential Internet access. CPS data from 2000, 2001, and 2003 document substantial regional variation in Internet access that could give rise to network externalities. Dial-up and high-speed access rates are given for nine regions of the U.S. (Figure 2).[5] For example, rural and urban households in the Pacific and New England regions have higher rates of high-speed access than the national average. Alternatively, the high-speed access rate in the West South Central region is well below the national average. This variation potentially generates higher benefits from network externalities in some regions than others. State-level residential rural and urban Internet access rates are included in Appendix A, and are denoted "regdensity" in the analysis that follows.

[5] The nine regions are based on the breakout used in the Current Population Survey supplement. Analysis of states comprising each region indicates that rates of residential Internet access between states in a region are relatively similar (Appendix A).

An important contribution of the current paper is the construction of state level rural and urban area measures of the availability of digital technology infrastructure. This measure is constructed from two separate data sources on cable Internet and Digital Subscriber Line (DSL) capacity.[6] Information on county-level cable Internet capacity is documented in the *Television and Cable Factbooks* for 2000, 2001, and 2003. Similarly, the Tariff #4 dataset available from the National Exchange Carriers Association (NECA) provides information on the DSL capability of every central office switch in the U.S (approximately 38,000 in 2003), along with the city or town served by each central office switch.[7] The 2000, 2001, and 2003 versions of the dataset are used to estimate DSL capacity in those years. A digital technology infrastructure index is then created for every county (or city) by weighting the capability of various technologies in that county (or city) by the population level.[8] In order to mesh this index with household data from the CPS, it is further aggregated to rural / urban areas within a state. Hence, the ultimate output from these data sources is the percentage of the population living in rural and urban areas of each state that have DCT infrastructure (either DSL or cable) available to them, or "DCT infrastructure capacity" (Appendix B).

[6] Cable and DSL accounted for 99 percent of the high-speed market in 2003, with satellite and wireless connections accounting for the other 1 percent (FCC, 2003).
[7] Tariff #4 data from 2003 indicates that most (59%) of these 38,000 central office switches are located by themselves, while the other 41% are co-located in “wire centers,” which house two or more switches. These switches may belong to many different telecommunications providers.
[8] Data on city / county population levels is taken from the 2000 census, provided by the Bureau of Labor Statistics.

A country-level summary of the share of rural and urban population with DSL and cable Internet capacity in their counties is presented in Table 3.[9] While 2003 saw dramatic increases in the percentage of both rural and urban populations with cable and DSL high-speed infrastructure capacity, rural areas still lag behind urban areas. Further, the percentage point gap is growing for cable Internet capacity. The diffusion of DCT infrastructure has also been very different for various regions of the country. Information on DCT infrastructure capacity in rural and urban areas of the nine regions of the U.S. depicted in Figure 2 is provided in Table 4 for the years 2000, 2001, and 2003. Several patterns are noticeable. Looking first at DSL, the capacity has increased remarkably in the south - particularly in the rural areas. For all rural areas, DSL capacity increased from 6.39 percent in 2001 to 29.55 percent in 2003 (an impressive 362 percent increase). However, in the southern regions (South Atlantic, West South Central, and East South Central), rural households saw increases of 401 percent, 637 percent, and 1,053 percent, respectively. This increase is consistent with BellSouth's aggressive deployment of DSL starting in late 2001 (Pinkham Group, 2002). Other rural areas, such as those in the Mountain, Middle Atlantic, and New England regions, continued to have relatively low DSL capacity through 2003. Additionally, the diffusion of DSL capacity has slowed for rural households in the Pacific and East North Central regions. While these regions had relatively high capacity in 2000, their growth rates did not keep pace with those for rural regions in the rest of the country. Finally, it is worth noting that the rural – urban discrepancy in capacity has shown different trends in various regions of the country. For instance, the Pacific region has consistently seen DSL capacity in rural areas lag behind

[9] Infrastructure data on cable is available only at the county level, but DSL data is available at the city level, which allows for a lower level of detail on the percentage of the population with infrastructure capacity.

that in urban areas by approximately 25 percentage points from 2000 through 2003. On the other hand, the rural population in the West North Central region has gone from lagging their urban counterparts by 8 percentage points in 2000 to being 9 percentage points *higher* in 2003! Alternatively, the gap has increased in the East North Central region, going from 6 percentage points in 2000 to 17 percentage points in 2003.

Cable Internet diffusion has also shown different trends in various regions of the country. Most of the diffusion occurred between 2001 and 2003, with capacity increasing by 39 percentage points in rural areas and 48 percentage points in urban areas. For all regions, rural areas experienced increases in capacity during this period, but none quite as dramatic as the West South Central region. Cable Internet capacity stood at less than 2 percentage points for the rural population in this region in 2001, and then skyrocketed to 46 percentage points in 2003 – a 2,213 percent increase! Similarly, in the Mountain region cable Internet capacity increased from 15 percentage points to 74 percentage points over this period. The diffusion was less striking in rural areas of the East South Central region, with capacity increasing from 5 percentage points to 25 percentage points. In general, the rural – urban gap in cable Internet capacity has increased between 2000 and 2003 (from 20 percentage points to 32 percentage points), but significant variance exists within the country. The biggest change is in the Pacific region, where rural areas actually have *higher* rates of cable Internet capacity in 2003 than urban areas (70 percentage points to 66 percentage points). This is drastically different from 2000, when rural rates were 25 percentage points below urban rates. The East North Central region has been relatively consistent over this period, with rural rates lagging urban rates by approximately 12 percentage points each year. On the other hand, the diffusion of cable Internet capacity in the Mountain region has occurred mainly in urban areas, as the urban – rural discrepancy increased from 13 percentage points in 2000 to 47 percentage points in 2003.

Thus, the exposure of the population to DCT infrastructure has varied not only across rural and urban areas generally, but by region of the country. The role of this uneven distribution of DCT infrastructure in the rural – urban digital divide is of yet undetermined. Further, because the majority of both rural and urban households still connect with dial-up access, the role of DCT infrastructure in the general digital divide may be smaller than its role in the emerging high-speed digital divide. The next section discusses the empirical model employed to understand the contribution of DCT infrastructure and other factors to the rural – urban digital divide in general and high-speed residential Internet access in particular.

Methodology

Basic Empirical Specification

The basic statistical model for capturing the influence of the factors discussed above (household characteristics, network externalities, and DCT infrastructure) on Internet adoption is specified as

$$y_i^* = X_i\beta + Z_i\delta + H_i\gamma + D1_i\tau_1 + D2_i\tau_2 + N_i\pi + \varepsilon_i \qquad (1)$$

$$y_i = 1 \;\; if \;\; y_i^* \geq 0$$

$$y_i = 0 \;\; \text{if} \;\; y_i^* < 0$$

where y_i^* is a latent measure of the benefits from residential Internet access relative to the costs of household *i*, y_i is the actual observation of household Internet access, X_i is a vector of household income levels, Z_i is a vector of household education levels, H_i is a vector of other household characteristics, $D1_i$ and $D2_i$ are the measures of DSL and cable availability discussed in the previous section (dslaccess and cableaccess), N_i is a measure of the regional rate of Internet access (regdensity); $\beta, \delta, \gamma, \tau_1, \tau_2, \pi$ are the respective associated parameter vectors, and ε_i is the statistical model's error term. Due to the discrete nature of the Internet adoption decision, a logit model is employed.[10]

Results

Parameter estimates for the household general access decision are presented in Table 5. Parameter estimates for most of the independent variables have the expected signs for the general access model. In particular, for all years, the parameter values for education are positive, and increase as the level of education increases. This implies that, relative to a household headed by an individual with no high school education, higher levels of education increase the relative odds of a household having Internet access. Similarly, the parameter values for income are significantly positive after income reaches $20,000 (faminc6). These parameters increase in value as the income level rises, meaning that the propensity for Internet access increases with income. Additionally, for 2001 and 2003, the presence of Internet access at work (netatwork), a married household head, and the presence of one, two, or three children all positively impact the probability of Internet

[10] Given this discrete nature, any binomial variable statistical model could have been chosen. However, the logit model had several benefits over its competitors – namely, that it restricts outcomes to the [0,1] interval (unlike the Linear Probability Model) and provides a closed form solution (unlike the probit model).

access. The significant positive coefficient on regdensity indicates that local connectivity rates are important in the Internet access decision, with higher local rates resulting in increased probability of access for a household. The age of the household head is also positively related to access in all years; however, the negative coefficient on age2 indicates that the positive influence of age reaches a maximum and then starts to decline. Households headed by Blacks and Hispanics are less likely to have Internet access for all years, while households headed by other non-White racial groups are less likely to have access in 2000 and 2003. Several variables are notably lacking significance. First, the availability of cable (cableaccess) and DSL access (dslaccess) are not significant. Rural status of the household (nm) is also insignificant in 2001 and 2003. This implies that, after controlling for other variables such as education, income, and other household characteristics, DCT infrastructure capacity and rural / urban status of the household do not strongly influence the probability of general Internet access. The results also imply that differences in education, income, and network externalities between rural and urban households are likely more important in explaining the general access digital divide than are differences in DCT infrastructure.

Model estimates with the same set of variables in the high-speed access decision yield similar parameter estimates for many variables (Table 6). In particular, higher levels of income and education increase the probability of high-speed access relative to households headed by individuals with low-income (under $5,000 per year) and low education levels (no high school diploma). However, only higher income levels (faminc10 - $40,000 or higher) are significant in most of the regressions, and the parameter values jump significantly for the highest level of income. Hence, having the highest level of income (faminc13 - $75,000 or more) may be particularly important in determining high-speed access. Internet access at work (netatwork) continues to be positively associated with high-speed access, as does the proxy for network externalities (regdensity). Meanwhile, households headed by Blacks and by Hispanics are still less likely to have high-speed access than Whites and non-Hispanics, respectively.

The high-speed access model does exhibit a number of noteworthy differences from the model for general access. First, rural status of the household has a significant and negative effect on high-speed residential Internet access in the years 2001 and 2003. This implies that even after controlling for differences in household characteristics (such as education and income) between rural and urban households, location in a rural area decreases the probability of high-speed access. Similarly, DSL capacity parameter estimates are positive and significant in 2001 and 2003, meaning that higher DSL infrastructure capacity was a significant factor for high-speed access. Interestingly, the coefficient for cable access is negative in 2001, implying that higher availability of cable Internet *decreased* the probability of high-speed access in this year, but was not significant in 2000 and 2003. Another distinct difference between the high-speed and general access model results is the lack of significance of chld1, chld2, or chld3 parameter estimates in any of the years. Apparently, the presence of children in the household does not play a significant role in the high-speed adoption decision. This result is somewhat surprising as large bandwidth is necessary for many common Internet activities of children under the age of 18, such as music downloading and on-line gaming

(Horrigan, 2004). Another surprising result is the lack of significance of the age term (peage) in 2000 and 2001, with only marginal significance in 2003. However, the quadratic age term (age2) is negative and at least marginally significant in all years, suggesting that the adoption propensity decreases rapidly with the age of the household head. If young families are most likely to have high-speed access, this may in part explain the lack of significance of children. Finally, households headed by a male are more likely to have high-speed access in all years. This is in direct contrast to the model for general access, where the sex of the household head was not significant in any year. The result is, however, reminiscent of the early days of dial-up adoption when a significant gender divide existed (Bimber, 2000).

Hence, significant differences do exist between the high-speed and general access logit model results. This implies that the contribution of a group of characteristics to the rural – urban digital divide could vary dramatically depending on the type of access in question. The following section provides a more formal assessment of the importance of individual factors to the rural – urban digital divide in general and high-speed access.

Decomposition of the Logit Model

A decomposition technique is employed to determine the contribution of each factor to the rural – urban digital divide. The technique used is a non-linear version of the Oaxaca-Blinder (Oaxaca, 1973; Blinder, 1973) decomposition, due to the non-linear nature of the logit model.[11] The standard (linear) Oaxaca-Blinder decomposition of the general rural – urban digital divide in residential Internet access can be expressed as:

$$\overline{Y}^U - \overline{Y}^R = (\overline{X}^U - \overline{X}^R)\hat{\beta}^U + \overline{X}^R(\hat{\beta}^U - \hat{\beta}^R) \tag{2}$$

where $\overline{Y}^G$ is the average value of Internet access, $\overline{X}^G$ is a row vector for average values of the independent variables, and $\hat{\beta}^G$ is a vector of coefficient estimates for rural / urban status *G*. Following Fairlie (2003), the decomposition for a non-linear equation, such as $Y = F(X\hat{\beta})$, can be written as:

$$\overline{Y}^U - \overline{Y}^R = \left[\sum_{i=1}^{N^U}\frac{F(X_i^U\hat{\beta}^U)}{N^U} - \sum_{i=1}^{N^R}\frac{F(X_i^R\hat{\beta}^U)}{N^R}\right] + \left[\sum_{i=1}^{N^R}\frac{F(X_i^R\hat{\beta}^U)}{N^R} - \sum_{i=1}^{N^R}\frac{F(X_i^R\hat{\beta}^R)}{N^R}\right] \tag{3}$$

where N^G is the sample size for rural / urban status *G*. Equation (3) applies urban and rural coefficient estimates to the two distinct groups of explanatory variables, X_i^U and X_i^R. Equivalently, the decomposition can be written as:

$$\overline{Y}^U - \overline{Y}^R = \left[\sum_{i=1}^{N^U}\frac{F(X_i^U\hat{\beta}^R)}{N^U} - \sum_{i=1}^{N^R}\frac{F(X_i^R\hat{\beta}^R)}{N^R}\right] + \left[\sum_{i=1}^{N^R}\frac{F(X_i^U\hat{\beta}^U)}{N^U} - \sum_{i=1}^{N^R}\frac{F(X_i^U\hat{\beta}^R)}{N^U}\right] \tag{4}$$

This first term on the right hand side of equations (3) and (4) represents the part of the digital divide due to group differences in the distributions of the explanatory variables *X*. The choice of which set of parameters to use (either $\hat{\beta}^U$ in (3) or $\hat{\beta}^R$ in (4)) is the essence of the familiar "index problem" to the Oaxaca-Blinder decomposition, and can be the source of significantly different results. Some studies suggest weighting the parameters by using coefficient estimates from a pooled sample of the two groups (Neumark, 1988; Oaxaca and Ransom, 1994). This approach results in the use of

[11] This non-linear version of the Oaxaca-Blinder decomposition is similar to the procedure used in Mills and Whitacre (2003) and Fairlie (2003).

weighted average parameters ($\hat{\beta}$ instead of $\hat{\beta}^U$ or $\hat{\beta}^R$), and is valid when the "weighted average" access rates are considered exemplary of the rates that would exist in the absence of a digital divide (Oaxaca and Ransom, 1994).

In order to calculate the contributions from individual explanatory variables included in the first term of (3) or (4), we must be able to “replace” a single rural characteristic (for example, education level) with its urban counterpart. Hence, a one-to-one mapping of the rural and urban samples is needed to establish an urban counterpart for each rural observation. In order to create such a mapping, predicted probabilities of Internet access are calculated for all observations (both rural and urban) using the specification in equation (1). Since the sample size for urban households is larger than the sample size for rural households, a sub-sample of urban households is randomly drawn equal in size to the rural sample. This sampling procedure will clearly affect $\overline{Y}^U$ and X_i^U , since both are dependent on the households included in the sample. However, as discussed below, results from the entire urban sample can be approximated by bootstrapping a large number of urban samples and averaging the results of the decomposition.

The two individual samples (the full rural sample and random urban sub-sample) are then ranked by predicted probability of Internet access. Hence, rural households that have characteristics placing them high (low) in their distribution are matched with urban households that have characteristics placing them high (low) in their distribution. To accomplish the decomposition, let X_1, X_2, and $X_3 \in X$ be the three distinct sets of independent variables discussed previously: X_1 represents household characteristics, X_2

represents network externalities, and X_3 represents telecommunications infrastructure. Using coefficient estimates $\hat{\beta}$ from a logit regression of a pooled sample of both rural and urban households, the independent contribution of X_1 to the digital divide can be expressed as:[12]

$$\frac{1}{N^R}\sum_{i=1}^{N^R} F(\hat{\beta}_0 + X_{1i}^U\hat{\beta}_1 + X_{2i}^U\hat{\beta}_2 + X_{3i}^U\hat{\beta}_3) - F(\hat{\beta}_0 + X_{1i}^R\hat{\beta}_1 + X_{2i}^U\hat{\beta}_2 + X_{3i}^U\hat{\beta}_3). \qquad (5)$$

Similar expressions can be written for the contributions of X_2 and X_3. Hence, the contribution of each group of variables to the gap equals the change in average predicted probability from replacing the rural distribution with the urban distribution for that group of variables while holding the distributions of the other groups constant.[13] This technique is particularly useful because the sum of the contributions from the individual groups will be equal to the total contribution from all variables in the sample (Fairlie, 2003).

It is important to note that equation (5) deals *only* with the first term of the decomposition shown in equations (3) and (4). The second term in equations (3) and (4) above represents the portion of the gap due to rural - urban differences in underlying parameters, and is not affected by differences in explanatory variables. The three categories of independent variables discussed above, along with this residual portion, make up the entire rural - urban digital divide in any given year. Thus, the framework

[12] Note that since a pooled sample is used to obtain coefficient estimates, the decomposition uses weighted averages of the parameter estimates shown in equations (3) and (4).
[13] Because of the non-linear form assumed by the use of the logit model, the contributions of X_1, X_2, and X_3 depend on values of the other variables. Hence, the order of how the variables enter equations (3) and (4) may affect their individual contributions to the rural-urban digital divide. To account for this, the order in which variables enter the analysis will be varied, and the results will be compared.

will be useful in determining the roles played by the various categories for any given time period.

General Access Decomposition Results

The results of the non-linear decomposition for general Internet access in 2000, 2001, and 2003 are presented in Table 7.[14] The first two rows of Table 7 indicate the share of rural and urban households with Internet access, and the third shows the resulting "digital divide" for each of the three years of CPS data. The remainder of the table reports the individual contributions from rural – urban differences in education, income, other household characteristics, network externalities, and DCT infrastructure.

The difference between rural and urban general Internet access rates ranges from 12.8 percentage points in 2003 to 13.8 percentage points in 2000. As expected, differences in education and income levels explain a large portion of this gap. Lower levels of education in rural areas account for between 17 and 22 percent of the gap, while lower levels of income account for between 34 and 36 percent of the gap. Differences in network externalities also play an important role, as they make up between 29 and 40 percent of the gap in a given year. Other household characteristics do not have much explanatory power, consistently making up less than 1 percent of the gap. However, given the results of the general logit model (discussed in the previous section), the minimal contribution of those factors grouped under “other household characteristics” could mask significant offsetting effects, such as the positive impact of children in the

[14] Unless noted otherwise, all decompositions use 1,000 random samples of urban households. The results remain essentially unchanged when either 100 or 10,000 random samples were used.

household or the negative impact of a Black or Hispanic household head. Rural – urban differences in DCT infrastructure explain very little, comprising only between –0.1 to 4 percent of the gap. The decompositions indicate that group differences in all of the included variables explain between 87 and 97 percent of the gap in general access. These high shares of the gap explained by characteristic differences suggest that only a relatively small portion of the gap (between 3 and 13 percent) is left unexplained by the included variables and is attributable to parameter differences in rural and urban areas.

The non-linearity of the logit model implies that the results may be sensitive to the order in which the variables are included. To explore this possibility, Table 8 reverses the order of the explanatory variables. Most of the estimates are very similar to those obtained with the original ordering; however two significant shifts occurred in the 2000 estimate. The role played by education jumps from 19 percent under the initial orderings to 26 percent when the orderings are reversed, and other household characteristics shift from explaining –2 percent of the divide to explaining –9 percent. The total contribution remains the same in both cases because the sum of the individual contributions necessarily equals the first term on the right-hand side of equations (3) and (4). As Fairlie (2003) notes, the sensitivity of the order in which the variables are introduced is dependent on the initial location in the logistic distribution and the movement inflicted on this distribution by switching characteristics of rural and urban households. Fairlie suggests experimenting with the ordering in order to verify the robustness of the results. While there are 5! = 120 different orderings for 2000, 2001, and 2003, approximately 10 different orderings were attempted for each year, with all estimates lying in the intervals created by the results in Tables 7 and 8. Thus, while some differences exist when the ordering is varied, the dominant factors remain the same in all years.

High-speed Access Decomposition Results

Comparable results are obtained when a similar decomposition is performed for high-speed access. High-speed access rates for rural and urban areas over the period 2000 – 2003 are shown in the first two rows of Table 9. As the third row of the table indicates, the high-speed divide has increased from 3 percentage points in 2000 to 14 percentage points in 2003. Turning to the contributions of various factors, education differences make up between 5 and 9 percent of the divide over these years, while income levels make up between 21 and 27 percent. It is interesting to note that the contribution of both of these factors is below their contributions to the general divide. Differences in other household characteristics consistently account for approximately 7 percent of the high-speed divide, which is far above their aggregate contribution to the general divide. Network externalities play the largest role in the high-speed divide, making up between 23 to 40 percent. This percentage is similar to the results for general access. DCT infrastructure differences make up approximately 6 percent of the divide in 2003, but actually *increase* the divide in 2000 and 2001. Reversing the order in which the variables were introduced produces the results shown in Table 10. Again, the results are similar under this re-ordering, with one exception being the impact of other household characteristics – switching from explaining around 7 percent in all years under the initial ordering to explaining –2 percent under the re-ordering. Additionally, the impact of education increases from between 5 – 9 percent to between 9 – 13 percent of the total gap. However, the dominant factors (income levels and network externalities) remain the same under this re-ordering. Including all of the variables explained between 55 and 83 percent of the high-speed access digital divide.

Discussion and Policy Implications

Historically, the primary course of action of the federal, state, and local governments to address the rural – urban digital divide has been to provide subsidies for DCT infrastructure in low-density regions (Leighton, 2001). However, the results of the decompositions indicate that the presence of DCT infrastructure is not a major factor in either the general or high-speed divide between rural and urban areas. Rather, differences in education and income, along with network externalities, are the most important factors for both the divide in general Internet access and the emerging divide in high-speed access.

Since DCT infrastructure is essentially a necessary condition for residential high-speed access, its lack of significance remains somewhat puzzling. One concern is whether the results change dramatically if network externalities are excluded from the model. Given that local rates of high-speed access may indicate some measure of DCT infrastructure capacity, the proxy for network externalities may be capturing some of the effects of such capacity. When the high-speed access decomposition is performed for this alternative specification, the impact of DCT infrastructure *does* increase, but not dramatically. For all years, differences in DCT infrastructure capacity make up between 1 and 8 percent of the high-speed divide. Meanwhile, income differences continue to account for over 22 percent of the divide. A second concern is that the aggregate nature of the DCT infrastructure measures may be masking underlying local relationships between infrastructure and high-speed access. Data constraints do not allow us to fully address this concern, and further research is needed on this issue.

Looking at the high-speed divide from a policy standpoint, the results indicate that efforts to close the emerging high-speed divide should focus on the underlying education and income gap between rural and urban areas. The importance of network externalities is also evident, but does this justify the presence of initial subsidies for high-speed access in areas with low adoption rates? The continued contribution of externalities for both dial-up and high-speed access lends support for such subsidies, and further research may need to identify the "tipping point" where the impact of subsidies is largest. The question of whether public policies should address DCT infrastructure also arises. While the analysis demonstrates that differences in DCT infrastructure capacity are not a driving force behind the divide, significant differences in capacity still exist between rural and urban areas. Initial evidence on diffusion is mixed, with the rural – urban gap in DSL capacity shrinking while the gap in cable Internet capacity is growing. Given the short time frame that these technologies have been available, market mechanisms may need additional time to diffuse capacity to more remote areas. The current analysis does not lend support for policies that promote infrastructure capacity in rural areas as the sole intervention to bridge the emerging gap in high-speed access.

References

Bimber, B. 2000. "Measuring the Gender Gap on the Internet." *Social Science Quarterly*. 81: 868-876.

Blinder, A. 1973. "Wage Discrimination: Reduced Form and Structural Variables." *Journal of Human Resources.* 8: 436-455.

Drabenstott, M. 2001. "New Policies for a New Rural America." *InternationalRegional ScienceReview*. 24, 1:3-15.

Fairlie, R. 2003. "An Extension of the Blinder-Oaxaca Decomposition Technique to Logit and Probit Models." *Economic Growth Center: Yale University*. Paper Number 873.

Federal Communications Commission – Industry Analysis and Technology Division. 2003. *High Speed Services for Internet Access: Status as of June 30, 2003*. Available at http://www.fcc.gov/wcb/iatd/comp.html

Horrigan, J.B. 2001. *Online Communities: Networks that Nurture Long-Distance Relationships and Local Ties*. Pew Internet & American Life Project. http://pewinternet.org/

Horrigan, J.B. 2004. *PEW Internet Data Project Memo: Home Broadband Adoption has Increased 60% in the past year and use of DSL Lines is Surging.* Pew Internet a& American Life Project. http://pewinternet.org/

Leighton, W.A. 2001. "Broadband Deployment and the Digital Divide." Cato Policy Analysis No. 410. August 7.

Malecki, E.J. 2003. "Digital Development in rural areas: potentials and pitfalls." *Journal of Rural Studies* 19: 201-214.

McConnaughey, J., and W. Lader. 1998. *Falling Through the Net II: New Data on the Digital Divide.* National Telecommunications and Information Administration, http://www.ntia.doc.gov/ntiahome/net2/falling.html

Mills, B.F. and B. Whitacre. 2003. "Understanding the Non-Metropolitan – Metropolitan Digital Divide." *Growth and Change*. 34,2: 219-243.

National Telecommunications and Information Administration and Economics Statistics Administration. 2000. *Falling Through the Net: Towards Digital Inclusion*. U.S. Department of Commerce: Washington, D.C.

Neumark, D. 1988. "Employers Discriminatory Behavior and the Estimation of Wage Discrimination." *Journal of Human Resources*. 23: 279-295.

Oaxaca, R. 1973. “Male-Female Differentials in Urban Labor Markets.” *International Economic Review*. 14: 693-709.

Oaxaca, R and M. Ransom. 1994. "On Discrimination and Decomposition of Wage Differentials." *Journal of Econometrics*. 61: 5-21.

Pearce, A. 2001. "Closing the Gap." America's Network. Sep. 1. Available at http://www.americasnetwork.com/americasnetwork/article/articleDetail.jsp?id=12

Pinkham Group. 2002. “DSL Deployment Analysis of RBOCs and Independent LECs in Metropolitan and Rural Areas – Q4 2001.” Available at http://www.dslprime.com/a/pinkham_deployment.htm

Prieger, J. 2003. “The supply side of the digital divide: Is there equal availability in the broadband Internet access market?” *Economic Inquiry*. 41,2: 346 - 363.

Rose, R. 2003. *Oxford Internet Survey Results.* The Oxford Internet Institute: The University of Oxford, UK.

Strover, S. 2001. "Rural Internet Connectivity." *Telecommunications Policy* 25: 331-347.

Warren Publishing Inc. 2000. *Television and Cable Factbook, Cable and Services.* Number 68: Cable Volumes 1-2. Washington, D.C.

Warren Publishing Inc. 2001. *Television and Cable Factbook, Cable and Services.* Number 69: Cable Volumes 1-2. Washington, D.C.

Warren Publishing Inc. 2003. *Television and Cable Factbook, Cable and Services.* Number 71: Cable Volumes 1-2. Washington, D.C.

Table 1. CPS Household Summary Data

	Urban			Rural		
	Total	Internet	Highspeed	Total	Internet	Highspeed
2000	26,413	12,368	1,456	8,601	3,045	218
2001	31,006	17,722	3,653	10,605	4,826	520
2003	29,841	18,456	7,524	10,331	5,333	1,300

Sources: CPS Computer and Internet Use Supplements, 2000, 2001, and 2003.

Table 2. Household Characteristics by Rural / Urban Status

		Urban			Rural		
		2000	2001	2003	2000	2001	2003
Family Characteristics	Variable Name						
Income							
Under $5K		2.95	2.84	3.06	4.62	4.28	3.98
$5K - $7.5K	faminc1	2.89	2.73	2.77	5.42	5.19	4.89
$7.5K - $10K	faminc2	2.97	2.92	2.92	4.42	4.36	4.11
$10K - $12.5K	faminc3	3.74	3.59	3.53	5.74	6.02	5.49
$12.5K - $15K	faminc4	3.35	3.33	3.13	5.19	5.33	5.33
$15K - $20K	faminc5	5.42	5.19	4.96	8.12	7.50	7.44
$20K - $25K	faminc6	6.95	7.04	6.38	9.56	9.13	8.80
$25K - $30K	faminc7	7.22	6.51	6.64	8.33	8.09	8.64
$30K - $35K	faminc8	6.77	6.28	6.75	7.67	7.43	7.78
$35K - $40K	faminc9	6.34	6.05	6.12	6.66	6.76	6.40
$40K - $50K	faminc10	9.22	9.87	9.54	10.19	9.34	9.04
$50K - $60K	faminc11	9.38	9.21	8.75	7.46	8.42	8.84
$60K - $75K	faminc12	9.55	9.66	9.87	6.94	7.08	8.38
$75K +	faminc13	23.26	24.76	25.58	9.67	11.07	10.87
Education							
No High School		13.33	12.86	12.12	19.90	19.03	17.87
High School	hs	26.60	26.62	26.29	37.20	36.75	36.67
Some College	scoll	27.63	28.35	27.94	25.40	26.88	27.54
Bachelor's Degree	coll	20.73	20.21	21.37	11.38	11.28	11.35
Higher than Bachelor's	collplus	11.73	11.95	12.27	6.12	6.05	6.57
Race / Ethnicity							
White		82.12	82.12	81.48	89.25	89.53	88.59
Black	black	13.22	13.19	12.40	8.06	7.92	7.70
Other	othrace	4.66	4.69	6.12	2.69	2.55	3.71
Hispanic	hisp	9.78	9.98	11.25	4.56	4.34	5.89
Household Composition							
Married	married	54.25	53.74	53.64	58.04	56.91	57.23
Age of Head	peage	47.06	47.16	47.22	49.81	50.09	50.03
Headed by Male	sex	55.26	53.90	53.71	57.37	55.84	55.12
No Children		68.13	65.46	66.06	70.53	67.06	67.85
1 child	chld1	13.95	14.67	14.29	13.31	13.83	13.24
2 children	chld2	12.76	13.11	13.09	11.21	12.10	12.33
3 children	chld3	3.58	4.90	4.75	3.52	4.91	4.66
4 children	chld4	1.14	1.41	1.46	0.91	1.56	1.30
5+ children	chld5	0.44	0.45	0.49	0.52	0.55	0.47
Employed Head	employed	70.29	69.33	68.09	64.50	63.03	61.08
Internet Characteristics							
Home	access	46.67	56.57	61.23	32.90	42.94	48.40
Work	netatwork	22.12	31.91	30.13	11.90	20.23	18.64
High Speed	highspeed	5.47	11.82	25.01	2.48	4.30	11.22

Note: Characteristics without variable names represent the "default" household

Sources: CPS Computer and Internet Use Supplements, 2000, 2001, and 2003.

Table 3. Percent of U.S. Rural / Urban Population with DCT Infrastructure Capacity

	2000	2001	2003
Cable			
Rural	4.66	5.47	44.10
Urban	25.08	27.68	75.75
DSL			
Rural	3.43	6.39	29.55
Urban	21.61	32.05	42.39

Sources: Cable Television Factbook, NECA Tariff #4 Data for 2000, 2001, and 2003.

Note: This table assumes that if the infrastructure exists within a rural or urban county (or city), the population of that county (or city) has infrastructure capacity.

Table 4. Percent of Rural / Urban Population Living in Counties with DCT Infrastructure

	DSL Infrastructure						Cable Infrastructure					
Region	2000		2001		2003		2000		2001		2003	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Pacific	11.74	36.74	23.32	57.16	34.81	59.89	11.45	36.06	14.68	41.73	70.03	65.61
Mountain	0.94	7.48	5.00	7.90	13.65	13.59	1.35	14.39	1.21	15.14	27.09	73.86
West North Central	1.24	9.63	3.22	5.56	26.53	17.01	4.18	31.04	5.14	32.77	42.67	78.22
West South Central	4.86	33.70	8.99	51.12	45.05	66.93	1.64	13.98	1.97	16.28	45.56	82.47
East North Central	5.07	11.65	6.17	34.34	23.47	40.16	8.83	20.36	10.11	25.50	59.57	71.93
East South Central	3.62	32.06	5.57	47.13	64.20	70.67	2.80	28.33	4.61	30.53	24.63	68.57
South Atlantic	1.58	15.11	4.97	28.82	36.64	51.94	1.85	26.60	2.44	30.31	40.12	73.71
Middle Atlantic	0.47	1.77	1.04	3.11	6.34	15.26	4.89	25.20	4.89	28.21	22.34	75.87
New England	0.00	0.00	0.36	2.29	10.10	19.18	7.85	30.07	7.74	30.07	55.53	78.83
Totals	3.43	21.61	6.39	32.05	29.55	42.39	4.66	25.08	5.47	27.68	44.10	75.75

Sources: Cable Television Factbook, NECA Tariff #4 Data for 2000, 2001, and 2003.

Note: This table assumes that if the infrastructure exists within a rural or urban county (or city), the population of that county (or city) has infrastructure capacity.

Table 5. Logit Model Results for General Internet Access

Dependent Variable: access									
	2000			2001			2003		
Variable	Coefficient	S.E.		Coefficient	S.E.		Coefficient	S.E.	
hs	0.6666	0.0601	***	0.6135	0.0520	***	0.6185	0.0510	***
scoll	1.2782	0.0609	***	1.1423	0.0531	***	1.2538	0.0528	***
coll	1.5698	0.0658	***	1.4229	0.0605	***	1.5520	0.0605	***
collplus	1.7100	0.0734	***	1.5497	0.0700	***	1.7105	0.0729	***
faminc1	-0.2491	0.1458	*	-0.2217	0.1239	*	-0.1569	0.1116	
faminc2	-0.1843	0.1458		-0.2127	0.1244	*	-0.2470	0.1155	**
faminc3	-0.1313	0.1307		0.0698	0.1096		-0.0628	0.1045	
faminc4	0.2247	0.1250	*	-0.0427	0.1123		-0.0333	0.1072	
faminc5	0.2090	0.1114	*	0.0768	0.1001		0.0902	0.0952	
faminc6	0.2491	0.1066	**	0.2972	0.0943	***	0.2605	0.0915	***
faminc7	0.4869	0.1053	***	0.4551	0.0946	***	0.3232	0.0900	***
faminc8	0.6995	0.1058	***	0.7215	0.0948	***	0.5116	0.0902	***
faminc9	0.6940	0.1067	***	0.7317	0.0961	***	0.7233	0.0936	***
faminc10	0.9629	0.1027	***	0.9637	0.0926	***	0.9508	0.0887	***
faminc11	1.1058	0.1042	***	1.1658	0.0940	***	1.1027	0.0925	***
faminc12	1.3663	0.1054	***	1.4011	0.0962	***	1.3726	0.0933	***
faminc13	1.7264	0.1026	***	1.8022	0.0931	***	1.6671	0.0905	***
netatwork	0.0614	0.0389		0.4892	0.0360	***	0.5325	0.0395	***
black	-0.8211	0.0520	***	-0.7439	0.0468	***	-0.6728	0.0482	***
othrace	-0.1375	0.0712	*	0.0208	0.0739		-0.1981	0.0704	***
hisp	-0.7281	0.0580	***	-0.6885	0.0560	***	-0.6647	0.0524	***
peage	0.0425	0.0062	***	0.0440	0.0055	***	0.0606	0.0059	***
age2	-0.0007	0.0001	***	-0.0007	0.0001	***	-0.0008	0.0001	***
sex	-0.0018	0.0306		-0.0218	0.0297		0.0118	0.0306	
married	0.4698	0.0334	***	0.5798	0.0332	***	0.5449	0.0339	***
chld1	-0.0793	0.0482		0.2067	0.0435	***	0.2515	0.0468	***
chld2	-0.0324	0.0490		0.3459	0.0475	***	0.2992	0.0511	***
chld3	-0.1361	0.0774	*	0.2659	0.0691	***	0.1913	0.0742	**
chld4	0.2424	0.1400	*	0.1515	0.1083		0.1484	0.1313	
chld5	-0.1259	0.1014		0.0883	0.1918		0.1944	0.2075	
regdensity	2.9113	0.2556	***	2.3981	0.2540	***	2.3540	0.2799	***
cableacces	0.0277	0.0950		-0.1041	0.0869		0.0094	0.0831	
dslaccess	0.1078	0.0675		0.0677	0.0596		0.0730	0.0608	
retired	0.0114	0.0648		0.0633	0.0576		0.1876	0.0575	***
nm	0.1142	0.0514	**	0.0352	0.0516		0.0620	0.0541	
constant	-3.9198	0.2059	***	-3.6942	0.2079	***	-3.9747	0.2463	***

***, **, and * indicate statistical significance at the *p* = 0.01, 0.05, and .10 levels, respectively

Table 6. Logit Model Results for High-speed Access

Dependent Variable: highspeed									
	2000			2001			2003		
Variable	Coefficient	S.E.		Coefficient	S.E.		Coefficient	S.E.	
hs	0.3163	0.1701	*	0.6210	0.1182	***	0.5498	0.0860	***
scoll	0.7519	0.1686	***	0.9818	0.1175	***	0.9864	0.0857	***
coll	0.9178	0.1726	***	1.1229	0.1209	***	1.1951	0.0891	***
collplus	0.8821	0.1793	***	1.0411	0.1260	***	1.2460	0.0934	***
faminc1	-0.7493	0.4632		-0.9969	0.2991	***	-0.3134	0.1702	*
faminc2	-0.5461	0.4506		-0.5521	0.2666	**	-0.4903	0.1748	***
faminc3	-0.3761	0.3810		-0.1605	0.2186		-0.3504	0.1591	**
faminc4	-0.1967	0.3694		-0.3315	0.2310		-0.3615	0.1603	**
faminc5	-0.1790	0.3211		-0.3509	0.2015	*	-0.2799	0.1410	**
faminc6	-0.1249	0.2941		-0.3236	0.1868	*	-0.1266	0.1299	
faminc7	0.3153	0.2852		-0.0909	0.1836		0.0216	0.1256	
faminc8	0.4778	0.2793	*	0.0905	0.1777		0.0434	0.1253	
faminc9	0.2053	0.2888		0.0979	0.1788		0.1034	0.1262	
faminc10	0.5184	0.2750	*	0.2759	0.1683		0.3310	0.1183	***
faminc11	0.6501	0.2787	**	0.3401	0.1690	**	0.4803	0.1188	***
faminc12	0.7301	0.2752	***	0.5921	0.1684	***	0.6228	0.1179	***
faminc13	1.1294	0.2700	***	0.9060	0.1641	***	1.0522	0.1153	***
netatwork	0.2278	0.0670	***	0.2496	0.0449	***	0.2748	0.0356	***
black	-0.4591	0.1212	***	-0.4599	0.0836	***	-0.4371	0.0605	***
othrace	-0.1497	0.1351		0.0861	0.0898		0.0437	0.0697	
hisp	-0.4301	0.1418	***	-0.3498	0.0968	***	-0.3470	0.0652	***
peage	0.0120	0.0140		0.0005	0.0092		0.0156	0.0075	**
age2	-0.0003	0.0002	**	-0.0002	0.0001	**	-0.0004	0.0001	***
sex	0.1757	0.0621	***	0.1653	0.0418	***	0.1589	0.0323	***
married	0.0688	0.0700		0.0810	0.0490	*	0.1593	0.0386	***
chld1	0.0147	0.0947		0.0353	0.0574		0.0781	0.0457	*
chld2	0.0721	0.0949		0.0043	0.0597		0.0683	0.0472	
chld3	-0.0533	0.1499		0.0044	0.0873		-0.0412	0.0721	
chld4	-0.0186	0.2716		0.0353	0.1545		-0.1879	0.1366	
chld5	0.1443	0.1906		-0.0348	0.2800		-0.1940	0.2300	
regdensity	12.3028	1.7871	***	3.8693	0.4967	***	2.6571	0.3019	***
cableacce:	-0.1503	0.1752		-0.2970	0.1102	***	0.1465	0.0913	
dslaccess	0.1101	0.1175		0.1683	0.0734	**	0.1586	0.0579	***
retired	0.0665	0.1514		0.0728	0.1041		0.0255	0.0787	
nm	-0.1646	0.1098		-0.5661	0.0769	***	-0.2717	0.0628	***
constant	-4.7240	0.4317	***	-3.4153	0.2728	***	-3.3133	0.2196	***

***, **, and * indicate statistical significance at the *p* = 0.01, 0.05, and .10 levels, respectively

Table 7. Logit Decomposition Results - General Access, 2000 - 2003

	Year		
	2000	2001	2003
Urban Household Internet Access Rate	0.4667	0.5657	0.6123
Rural Household Internet Access Rate	0.3290	0.4294	0.4840
Rural / Urban Gap	0.1377	0.1363	0.1283
Contributions from Rural / Urban Differences in:			
Education Levels	0.0264	0.0229	0.0279
	19.2%	16.8%	21.7%
Income Levels	0.0487	0.0489	0.0434
	35.4%	35.9%	33.8%
Other Household Characteristics	-0.0021	-0.0001	0.0010
	-1.5%	-0.1%	0.8%
Network Externalities	0.0553	0.0466	0.0376
	40.2%	34.2%	29.3%
DCT Infrastructure	0.0049	-0.0001	0.0035
	3.6%	-0.1%	2.7%
All included variables	0.1332	0.1182	0.1134
	96.7%	86.7%	88.4%

Note: Percentages indicate the contribution of each group of variables to the rural / urban gap for that year.

Table 8. Logit Decomposition Results - General Access, 2000 - 2003 (Reverse Order)

	Year		
	2000	2001	2003
Urban Household Internet Access Rate	0.4667	0.5657	0.6123
Rural Household Internet Access Rate	0.3290	0.4294	0.4840
Rural / Urban Gap	0.1377	0.1363	0.1283
Contributions from Rural / Urban Differences in:			
Education Levels	0.0360	0.0280	0.0304
	26.1%	20.5%	23.7%
Income Levels	0.0492	0.0476	0.0412
	35.7%	34.9%	32.1%
Other Household Characteristics	-0.0130	-0.0020	0.0015
	-9.4%	-1.5%	1.2%
Network Externalities	0.0561	0.0449	0.0374
	40.7%	32.9%	29.2%
DCT Infrastructure	0.0049	-0.0003	0.0029
	3.6%	-0.2%	2.3%
All included variables	0.1332	0.1182	0.1134
	96.7%	86.7%	88.4%

Note: Percentages indicate the contribution of each group of variables to the rural / urban gap for that year.

Table 9. Logit Decomposition Results - High-speed Access, 2000 - 2003

	Year		
	2000	2001	2003
Urban Household Internet Access Rate	0.0547	0.1182	0.2501
Rural Household Internet Access Rate	0.0248	0.0430	0.1122
Rural / Urban Gap	0.0299	0.0752	0.1379
Contributions from Rural / Urban Differences in:			
Education Levels	0.0026	0.0038	0.0117
	8.7%	5.1%	8.5%
Income Levels	0.0081	0.0156	0.0314
	27.1%	20.7%	22.8%
Other Household Characteristics	0.0022	0.0052	0.0103
	7.4%	6.9%	7.5%
Network Externalities	0.0120	0.0175	0.0401
	40.1%	23.3%	29.1%
DCT Infrastructure	-0.0001	-0.0010	0.0084
	-0.3%	-1.3%	6.1%
All included variables	0.0248	0.0411	0.1019
	82.9%	54.7%	73.9%

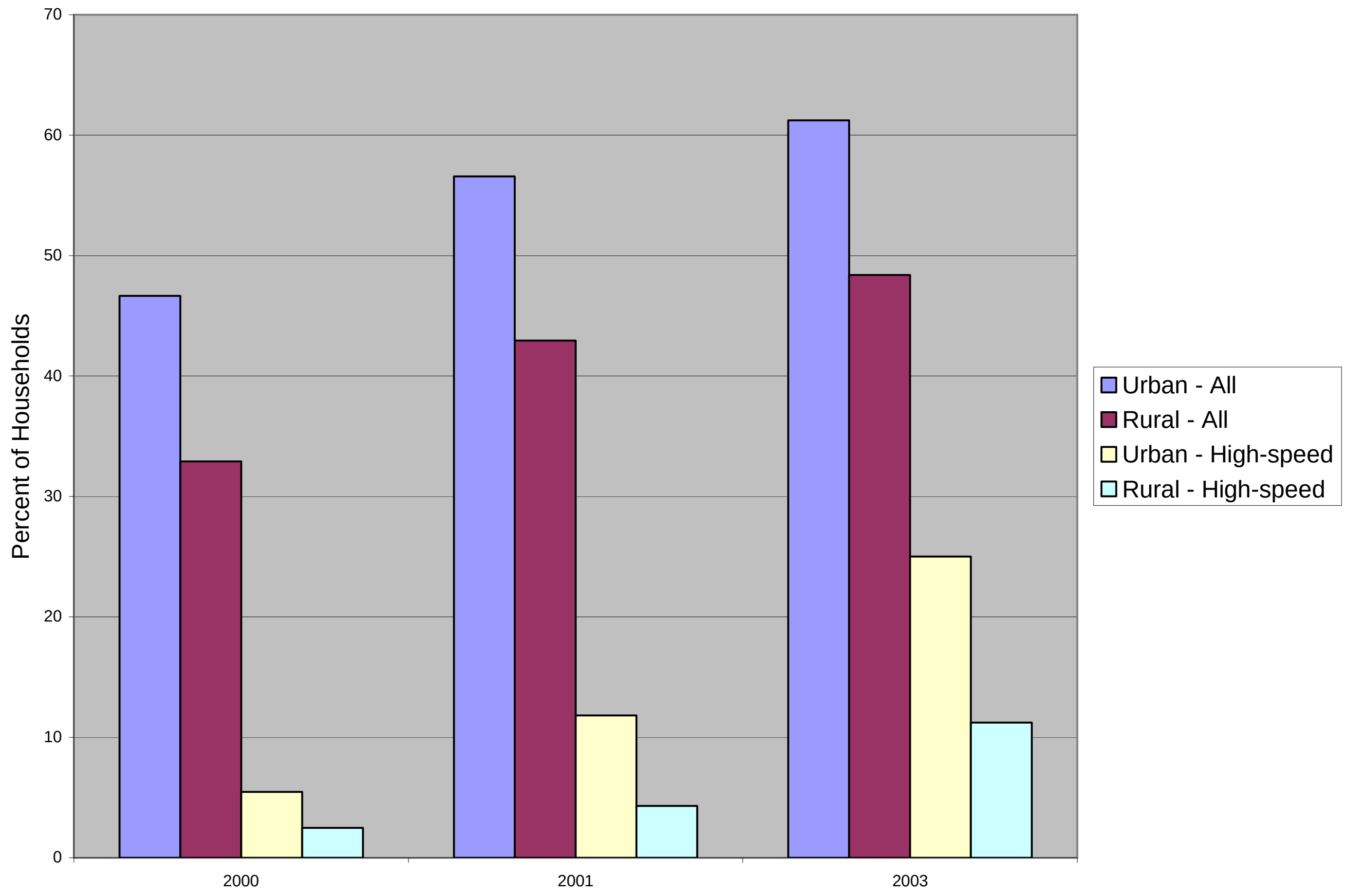
Note: Percentages indicate the contribution of each group of variables to the rural / urban gap for that year.

Table 10. Logit Decomposition Results - High-speed Access, 2000 - 2003 (Reverse Order)

	Year		
	2000	2001	2003
Urban Household Internet Access Rate	0.0547	0.1182	0.2501
Rural Household Internet Access Rate	0.0248	0.0430	0.1122
Rural / Urban Gap	0.0299	0.0752	0.1379
Contributions from Rural / Urban Differences in:			
Education Levels	0.0039	0.0069	0.0171
	13.0%	9.2%	12.4%
Income Levels	0.0087	0.0177	0.0310
	29.1%	23.5%	22.5%
Other Household Characteristics	-0.0007	-0.0015	-0.0006
	-2.3%	-2.0%	-0.4%
Network Externalities	0.0132	0.0195	0.0438
	44.1%	25.9%	31.8%
DCT Infrastructure	-0.0003	-0.0015	0.0106
	-1.0%	-2.0%	7.7%
All included variables	0.0248	0.0411	0.1019
	82.9%	54.7%	73.9%

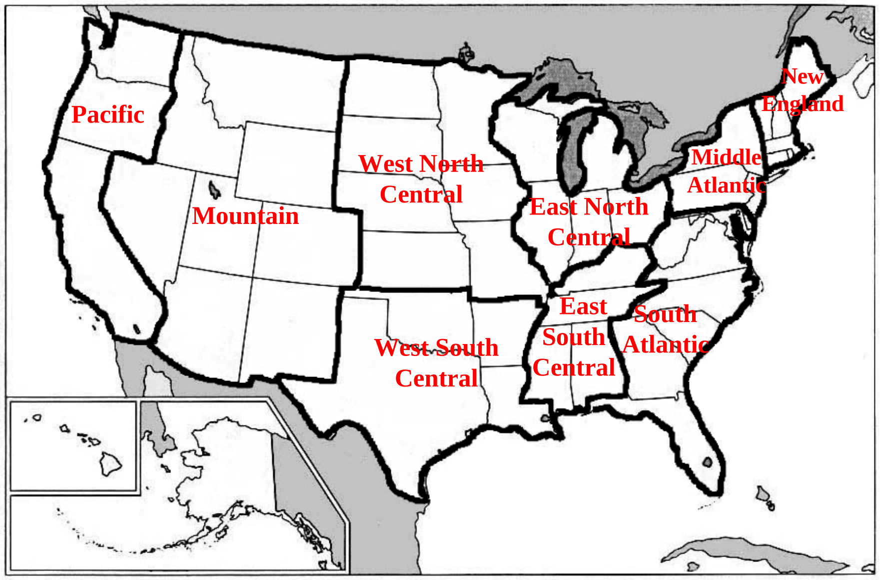
Note: Percentages indicate the contribution of each group of variables to the rural / urban gap for that year.

Figure 1. Residential Internet Access and the Rural - Urban Digital Divide



Sources: CPS Computer and Internet Use Supplements, 2000, 2001, and 2003.

Figure 2. Nine Regions of the U.S. and Residential Dial-up and High-Speed Access Rates (By Region)



Region	Dial-up						High-speed					
	2000		2001		2003		2000		2001		2003	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Pacific	39.31	48.81	44.20	46.18	42.95	36.47	2.88	6.64	6.12	17.89	16.68	29.46
Mountain	39.49	42.21	42.45	47.83	41.38	40.59	1.86	5.09	4.82	9.96	11.33	20.46
West North Central	30.30	42.21	39.42	45.48	37.05	36.68	2.29	5.77	4.43	12.64	13.17	27.32
West South Central	25.54	33.62	32.80	40.89	33.26	34.14	2.28	5.22	2.30	8.94	8.84	17.33
East North Central	33.89	41.28	43.88	46.10	39.68	37.33	2.01	4.20	2.69	8.51	9.15	21.47
East South Central	23.50	38.29	30.17	43.12	32.50	34.69	3.61	4.54	5.98	7.05	9.45	20.43
South Atlantic	28.92	39.83	36.23	45.73	35.64	37.62	2.42	4.83	3.02	9.62	9.75	22.95
Middle Atlantic	39.25	41.57	40.14	44.93	37.85	35.04	3.16	5.14	7.58	12.43	15.40	27.39
New England	48.83	43.96	52.11	45.57	45.98	36.01	2.06	7.46	6.73	15.91	17.90	30.95
Totals	30.42	41.20	38.64	44.75	37.18	36.22	2.48	5.47	4.30	11.82	11.22	25.01

Sources: CPS Computer and Internet Use Supplements, 2000, 2001, and 2003.

Appendix A

State-level Rates of Dial-up and High-speed Access: 2000, 2001, and 2003

	Dial-up						High-speed						Region
	2000		2001		2003		2000		2001		2003		
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	
Maine	37.03	37.72	47.12	46.40	44.22	39.90	3.32	9.86	6.49	16.08	14.37	26.64	
New Hampshire	59.88	46.27	52.90	45.63	41.42	34.49	3.52	8.71	9.90	19.04	24.03	36.39	
Vermont	45.31	51.72	46.76	49.47	45.12	40.79	1.42	7.00	7.33	17.50	13.53	34.08	New England
Massachusetts	53.10	41.16	61.66	42.17	53.17	33.33	0.00	8.40	3.19	15.72	19.66	30.40	
Rhode Island	N/A	35.44	N/A	44.73	N/A	31.22	N/A	5.96	N/A	12.56	N/A	27.96	
Connecticut	N/A	51.46	N/A	45.02	N/A	36.37	N/A	4.85	N/A	14.55	N/A	30.21	
New York	36.66	37.46	36.14	41.55	36.52	31.72	5.59	5.38	6.52	14.55	21.42	27.12	
New Jersey	N/A	45.24	N/A	48.94	N/A	35.08	N/A	5.97	N/A	13.42	N/A	31.62	Middle Atlantic
Pennsylvania	37.85	42.00	44.14	44.31	39.18	38.34	0.73	4.07	8.63	9.34	9.38	23.44	
Ohio	32.81	40.25	51.61	44.57	42.87	37.88	1.50	4.91	3.00	9.25	9.17	20.82	
Indiana	34.10	40.64	40.29	49.08	43.08	40.77	3.67	4.36	2.88	6.58	6.01	14.95	
Illinois	31.02	42.57	40.25	45.75	34.01	36.51	0.00	3.32	0.59	7.95	11.90	22.09	East North Central
Michigan	41.46	40.12	43.05	43.37	36.32	33.96	2.45	6.13	1.82	11.78	5.78	24.88	
Wisconsin	30.05	42.83	44.21	47.72	42.14	37.54	2.48	2.29	5.14	7.02	12.90	24.63	
Minnesota	27.94	45.18	39.69	53.98	36.75	45.69	3.20	5.62	3.64	9.96	14.21	24.15	
Iowa	29.02	40.98	42.40	47.19	38.32	42.55	2.60	6.23	6.67	13.24	14.41	25.90	
Missouri	32.71	41.90	48.01	43.33	35.68	41.30	1.78	7.61	4.67	10.13	7.76	22.39	
North Dakota	30.82	40.65	39.35	44.16	40.00	31.63	1.42	3.47	1.43	9.51	14.05	25.29	West North Central
South Dakota	31.92	40.73	32.79	47.54	30.80	32.48	1.97	4.39	8.57	14.28	19.31	30.85	
Nebraska	26.70	41.64	30.08	40.37	37.44	34.00	3.97	5.57	3.30	15.76	9.62	31.89	
Kansas	33.02	44.41	43.65	41.78	40.35	29.07	1.12	7.50	2.71	15.62	12.84	30.75	
Delaware	39.29	46.39	38.67	49.97	44.02	43.23	6.19	6.50	1.33	9.70	8.82	19.31	
Maryland	N/A	41.13	N/A	52.00	N/A	41.51	N/A	5.11	N/A	11.20	N/A	24.18	
DC	N/A	36.71	N/A	37.33	N/A	36.83	N/A	4.15	N/A	8.51	N/A	24.24	
Virginia	30.07	48.02	41.81	52.99	43.18	45.46	0.93	3.50	5.65	8.63	11.19	24.00	
West Virginia	25.74	37.61	34.83	42.88	35.48	34.97	2.03	5.04	2.48	6.58	10.53	21.61	South Atlantic
North Carolina	31.04	35.93	31.47	41.14	35.18	32.39	3.93	4.14	5.97	8.90	11.91	24.63	
South Carolina	25.35	30.48	34.76	41.63	31.32	30.13	0.00	5.21	1.43	10.97	9.90	20.77	
Georgia	17.90	42.67	28.09	48.39	29.41	36.59	0.92	3.70	3.13	10.07	10.94	25.61	
Florida	33.08	39.54	44.01	45.26	30.93	37.51	2.95	6.16	1.13	12.03	4.97	22.20	
Kentucky	26.35	41.58	42.43	46.44	39.37	45.06	3.72	6.01	2.65	3.91	8.54	19.47	
Tennessee	23.12	41.28	27.53	40.59	29.11	30.57	3.94	5.23	9.33	11.39	11.61	25.41	
Alabama	24.37	38.73	23.59	38.49	29.82	32.16	1.24	2.65	4.58	6.66	9.26	19.14	East South Central
Mississippi	20.17	31.58	27.12	46.97	31.68	30.98	5.53	4.28	7.36	6.25	8.39	17.71	
Arkansas	21.63	29.16	28.81	38.05	28.82	33.07	1.92	2.84	3.53	4.92	13.27	14.61	
Louisiana	31.62	30.63	38.31	36.29	35.08	34.25	0.94	5.03	1.64	7.46	3.26	14.44	
Oklahoma	24.45	36.63	30.60	47.98	34.61	34.15	4.44	7.47	2.97	11.58	10.55	17.88	West South Central
Texas	24.47	38.06	33.50	41.23	34.53	35.08	1.84	5.55	1.07	11.79	8.30	22.39	
Montana	41.80	38.11	46.90	47.12	40.77	38.90	1.60	4.04	2.74	6.42	9.24	14.90	
Idaho	38.77	47.25	48.62	45.97	45.88	44.21	1.99	3.75	5.03	13.22	13.39	18.03	
Wyoming	43.07	45.56	44.03	56.40	44.22	48.04	1.99	1.48	6.76	6.63	13.38	14.41	
Colorado	40.75	49.05	43.80	50.19	51.08	40.34	2.64	5.89	6.22	11.71	10.00	27.03	Mountain
New Mexico	26.84	36.48	31.25	49.73	39.77	42.06	1.41	6.67	2.70	3.18	4.37	10.76	
Arizona	30.22	40.31	36.37	40.08	32.17	31.76	0.00	7.40	6.55	15.45	16.81	25.87	
Utah	47.20	46.37	40.91	44.56	39.33	46.65	3.20	5.33	5.38	15.08	14.42	23.84	
Nevada	47.30	34.56	47.72	48.59	37.84	32.77	2.09	6.20	3.21	8.04	9.01	28.82	
Washington	27.23	47.91	42.41	50.58	40.12	36.00	3.63	6.53	1.17	15.89	13.66	32.91	
Oregon	40.64	56.32	44.71	49.96	44.74	46.27	2.40	3.96	8.30	12.49	12.58	22.53	
California	42.54	43.48	35.25	44.20	40.93	36.09	4.72	6.51	4.98	15.63	10.50	29.30	Pacific
Alaska	46.97	55.90	53.79	52.07	50.17	40.60	3.66	7.60	8.85	19.17	19.59	30.31	
Hawaii	39.15	40.46	44.84	34.09	38.81	23.41	0.00	8.63	7.30	26.29	27.09	32.27	

Appendix B
State-level Rates of DCT Infrastructure Capacity (Cable and DSL)
2000, 2001, and 2003

These numbers represent the percentage of rural / urban population within each state that had DSL or Cable access within their city (for DSL) or county (for Cable) of residence.

	DSL						Cable						
	2000		2001		2003		2000		2001		2003		Region
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	
Maine	0.00	0.00	1.07	1.32	6.10	5.76	11.41	15.33	10.76	15.33	57.61	87.92	
New Hampshire	0.00	0.00	0.00	0.00	6.86	1.46	11.42	32.85	11.42	32.85	71.52	73.16	
Vermont	0.00	0.00	1.10	5.58	8.01	5.58	0.00	0.00	0.00	0.00	45.68	53.81	New England
Massachusetts	0.00	0.00	0.00	6.84	0.00	9.40	0.00	27.19	0.00	27.19	58.39	92.24	
Rhode Island	0.00	0.00	0.00	0.00	0.00	19.55	0.00	70.80	0.00	70.80	0.00	76.32	
Connecticut	0.00	0.00	0.00	0.00	39.62	73.32	24.25	34.24	24.25	34.24	100.00	89.56	
New York	0.00	2.70	1.67	3.61	7.18	30.44	0.00	13.10	0.00	13.64	12.00	96.78	
New Jersey	0.00	0.00	0.00	0.00	0.00	3.61	0.00	32.85	0.00	32.85	0.00	73.16	Middle Atlantic
Pennsylvania	1.40	2.62	1.44	5.72	11.85	11.73	14.68	29.67	14.68	38.16	55.03	57.65	
Ohio	13.00	6.90	14.15	26.85	39.63	41.59	4.62	22.01	6.02	22.01	72.97	70.59	
Indiana	3.13	16.86	5.49	47.80	27.17	61.35	18.51	14.59	18.70	18.65	80.86	56.79	
Illinois	4.67	32.75	4.67	54.32	12.09	39.20	1.46	22.68	6.13	40.57	25.12	85.79	East North Central
Michigan	4.55	0.68	4.55	18.61	10.26	20.62	18.21	40.42	18.21	45.16	47.57	70.56	
Wisconsin	0.00	1.03	1.98	24.10	28.20	38.05	1.37	2.11	1.51	1.08	71.35	75.91	
Minnesota	0.85	0.00	1.96	5.04	9.38	9.43	5.76	4.03	5.90	4.16	32.32	100.00	
Iowa	0.07	0.00	0.66	0.74	15.95	9.36	0.44	53.20	3.17	53.84	37.73	73.16	
Missouri	6.37	19.13	6.36	24.48	33.02	46.69	0.00	3.59	0.07	7.04	18.38	29.13	
North Dakota	0.00	0.00	1.71	0.00	47.77	1.78	0.52	30.10	0.78	30.10	48.42	87.67	West North Central
South Dakota	0.00	0.00	9.07	0.00	28.36	0.79	17.38	42.77	19.13	45.78	59.36	100.00	
Nebraska	0.00	0.00	1.41	0.00	9.70	1.34	0.00	76.12	0.29	76.23	48.29	81.34	
Kansas	1.37	48.25	1.37	8.68	41.56	49.65	5.17	7.48	6.64	12.21	54.20	76.24	
Delaware	0.00	0.00	0.00	9.48	0.00	9.48	0.00	80.18	0.00	80.18	19.08	90.10	
Maryland	0.00	0.00	0.00	16.09	0.00	17.48	0.00	40.95	0.00	40.95	41.44	68.52	
DC	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	100.00	
Virginia	9.89	15.47	7.51	27.37	45.32	30.77	5.64	31.92	5.64	36.22	23.77	59.52	
West Virginia	0.00	0.00	0.00	0.33	6.71	39.65	0.00	0.00	0.00	21.34	36.81	61.88	South Atlantic
North Carolina	0.52	40.50	24.32	67.58	78.47	85.43	1.24	8.17	1.24	8.17	55.07	91.62	
South Carolina	3.82	24.35	4.33	45.86	59.78	61.44	8.45	15.33	8.45	15.89	93.14	57.68	
Georgia	0.00	29.08	2.16	51.68	70.86	75.17	1.30	46.11	6.62	46.47	29.74	53.68	
Florida	0.00	26.61	6.41	41.00	68.58	48.01	0.00	16.75	0.00	23.56	62.04	80.37	
Kentucky	7.78	19.20	8.91	35.84	60.90	53.88	0.73	60.14	0.73	60.47	15.67	70.24	
Tennessee	1.87	54.07	5.90	66.16	70.64	89.30	2.82	39.01	2.82	41.43	26.44	84.14	
Alabama	3.65	31.97	6.32	49.19	51.51	66.80	3.38	6.72	7.65	8.44	28.36	63.69	East South Central
Mississippi	1.16	23.02	1.16	37.35	73.75	72.70	4.26	7.45	7.23	11.78	28.05	56.23	
Arkansas	0.00	16.64	7.59	42.40	36.02	67.90	5.60	6.10	5.60	13.32	65.17	100.00	
Louisiana	3.56	38.63	6.90	52.98	74.39	74.14	0.00	33.47	0.00	34.54	47.30	70.16	
Oklahoma	0.00	56.88	3.36	50.51	30.91	56.63	0.88	0.00	0.88	0.91	31.18	93.67	West South Central
Texas	15.89	22.63	18.12	58.59	38.88	69.04	0.10	16.33	1.40	16.35	38.59	66.06	
Montana	0.00	0.00	14.47	0.00	25.44	26.51	0.49	0.00	0.49	0.00	10.74	55.94	
Idaho	2.56	5.80	2.56	5.80	8.66	5.80	0.32	0.00	0.32	0.00	49.45	54.01	
Wyoming	0.00	0.00	0.00	0.00	1.56	0.00	3.56	0.00	3.56	0.00	24.85	92.16	
Colorado	0.00	0.00	12.81	0.00	26.29	3.73	0.00	13.74	0.00	17.01	4.72	74.34	
New Mexico	0.00	0.00	0.00	0.00	21.12	0.00	0.00	28.81	0.00	28.81	12.00	70.53	Mountain
Arizona	0.00	0.09	0.00	0.09	8.02	9.49	2.19	0.00	1.10	2.68	48.95	100.00	
Utah	0.00	0.00	4.44	0.00	12.44	0.44	0.00	2.98	0.00	2.98	0.18	46.37	
Nevada	4.96	53.97	5.70	57.34	5.70	62.78	4.22	69.61	4.22	69.61	65.79	97.50	
Washington	11.09	16.47	25.01	23.60	39.34	27.05	44.51	31.72	44.51	52.32	84.62	73.60	
Oregon	6.73	16.49	20.93	18.25	40.38	28.46	1.13	29.50	17.27	34.89	77.09	78.41	
California	11.74	75.68	27.37	83.34	31.88	83.33	10.24	23.02	10.24	25.37	54.35	64.39	Pacific
Alaska	0.00	0.00	14.15	85.53	33.30	85.53	1.38	0.00	1.38	0.00	100.00	13.19	
Hawaii	29.16	75.07	29.16	75.07	29.16	75.07	0.00	96.07	0.00	96.07	34.07	98.44	